Baylor Interdisciplinary Material Science and Engineering Program Proposal

Proposal prepared by Material Science and Engineering Feasibility Committee:

Members
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Summary of the proposal given at the Engineering and Computer Science Board of Advocates Meeting, October 4, 2017

Societal Impact of Material Science Engineering

• Many recent discoveries and advancements in materials science engineering have improved people’s lives and reshaped societies
  • Lasers – 1958
  • Semiconductors – 1960
  • Soft Contact Lenses – 1971
  • In 2008, Materials Today lists the top 10 Advances in Materials Science in the last 50 years
  • Semiconductors
  • Scanning probe microscopes (STM, SEM, AFM, Raman etc.)
  • Giant magnetoresistive effect (GMR)
  • Semiconductor lasers and LEDs
  • National nanotechnology initiative (NNI)
  • Pro-Futuris – Five Year Goal – Compelling Scholarship
  • "Pro Futuris calls Baylor to be a place where research discoveries illuminate solutions to significant challenges confronting our world and where creative endeavors reflect the breadth of God’s creation." – Pro-Futuris

Current Strengths in MSE Research at Baylor

• There are many faculty already involved in materials science and engineering research at Baylor (well over 40 faculty researchers)
• The current funding from the faculty who may be affiliated, even loosely, with MSE (OVPR statistics) is listed at $4.23 million
• The two current areas that will serve as the initial anchor for the program
  • Optoelectronics
    • 10 faculty already at Baylor
    • Current funding of $670 K
    • Established and diverse labs
  • Polymer Composites and Science
    • Four faculty already at Baylor
    • Current funding of $816 K
    • Established and diverse labs
• The two core areas have areas of overlap and multiple paths already exist for collaborations
The need for materials science engineering will continue to drive societal advancements, if not accelerate in the next half century.

This is a unique opportunity for Baylor University to contribute and make a difference in the world as the flagship evangelical university in the nation.

Materials Science Engineering is inherently interdisciplinary and crosses traditional boundaries in research and academia.

The lack of an MSE program is inconsistent with that of our peer and aspirant institutions.

MSE programs can dramatically improve the university’s standing through collaborative research opportunities and new degree offerings while simultaneously building stronger base programs at the department level.

An MSE program is in line with Pro Futuris in which Baylor aspires to national recognition as a “Carnegie classified Research University with very high research activity.”

The MSE committee proposes establishing an institute focused on materials (maybe called Baylor Institute for Materials Science and Engineering, BIMSE) to establish a larger research presence in this area.

The institute will host a multidisciplinary doctoral degree in MSE with specific course offerings that join existing departments across campus.

Initially many courses will be cross listed between MSE and the home departments (i.e., electronic materials, chemical kinetics, viscoelasticity, computational chemistry, etc.).

A core of MSE courses will be established.

Through judicious, targeted investments in faculty and infrastructure, Baylor can rapidly expand its degree offerings and enhance research capabilities.

BIMSE will be an interdisciplinary program that operates under the VPR’s office.

The advisory committee will be composed of the Deans from A&S and ECS and two faculty from each of A&S and ECS.

MSE will have a director/Coordinator.

Recruit a director to be hired in year 2 or 3. The new director will have an established international reputation in materials. The initial director will then transition to the role of Assistant Director to handle the detailed management of the program.

The Assistant Director will cycle between ECS and A&S on a regular basis.

In year 1 and 2, A&S and ECS will target several of their new faculty hires in MSE.

Both A&S and ECS have each committed to make two of their hires in MSE area.

In year three, two MSE faculty positions are requested.

In year four a cluster hiring of 5-10 faculty will initiate. These lines will be used by the director to recruit external faculty in targeted areas of research.

Staffing:

- Hire three research assistant professors over the first three years. The research assistant professors may serve as PI’s and co-PI’s and by year three be supported 50% by Baylor and 50% externally.
- There will be a need for a technician in year 1, an additional technician in year 3, and admin support.
### Needs
- **Faculty hires**
  - Some are already committed by A&S and ECS
  - New additional lines
- **Staffing hires**
  - Research Assistant Professors
  - Technicians
  - Administrative support
- **New collaborative projects with support of ~$150k/year in the first three years to serve as seed funding for larger externally sponsored research**
  - GA positions to nucleate new research funding with the goal to convert to RAs
- **Equipment**
  - AFM ($150k), High-res TEM ($2.3M), Sample prep devices ($400k), XPS ($500k), Ellipsometer ($58k), Confocal for thin films ($140k), EDS/EDAX ($80k), FTIR ($120k), machine shop, XRD, E-beam and Ion beam lithography, CVD systems, etc.
  - Some will be requested in the program proposal, some will be in conjunction with external support grants
- **Facility to jointly host the equipment**

### What does Baylor already have in MSE?
- **A foundation in optoelectronics research**
  - $670k in current funding
  - 11 faculty in four departments
  - Extensive equipment installed and in operation
- **A foundation in Polymer Composites**
  - $856k in current funding
  - 4 faculty
  - Extensive equipment installed and in operation
- **Over 15 courses presently offered that can serve as part of the MSE graduate curriculum**
  - A fairly extensive set of equipment for characterization, sample preparation, imaging, etc.
  - Equipment is spread out over multiple facilities and within multiple departments
  - Existing cordial agreements exist between individual PIs for equipment sharing

### Available Equipment
- JEM2100 High Resolution Transmission Electron Microscope (JEOL)
  - Resolution of 0.17nm at 200 kV
  - Dual beam FIB/IB microscope (FEI Nova NanoLab 600i)
  - Scanning Auger Microscope (PerkinElmer PHI 6600)
  - Helical imaging and quantification capability
  - Energy dispersive X-ray spectroscopy (EDS), wavelength dispersive X-ray spectroscopy (WDS), and wavelength dispersive electron spectroscopy (WDS-EDS)
  - High voltage capability (HV)
  - Environmental scanning electron microscopy (ESEM)
  - Cross section preparation (beam induced etching, focused ion beam, etc.)
  - Imaging and analytical capabilities
  - X-ray photoelectron spectroscopy (XPS)
  - Secondary electron imaging (SE)
  - Backscattered electron imaging (BSE)
  - Energy-dispersive X-ray spectroscopy (EDS)
  - Scanning transmission electron microscopy (STEM)
  - High-resolution scanning transmission electron microscopy (HR-STEM)
  - High-angle annular dark field scanning transmission electron microscopy (HAADF STEM)
  - Electron energy loss spectroscopy (EELS)
  - Electron holography
  - High-angle annular bright field scanning transmission electron microscopy (HABF STEM)
  - Electron tomography
  - Fast Fourier transform (FFT) image processing
  - Image analysis software (Digital Micrograph, ImageJ)
  - Sample preparation (cutting, polishing, coating)
  - Sample handling and manipulation (micromanipulators, sample holders)
  - Sample holders and mounts (for SEM, TEM, FIB, EBSD, etc.)
  - Technical support and training (in-house or external)
Available Equipment

PHYSICS
- Variable Temperature Scanning Tunneling Microscope (Specs) with supporting ULV system.
- Quadrupole Mass Spectrometer (SMR) with supporting UV system.
- Low Temperature Diffusion Cell (RBB), Kohler Thrust Evaporator (Vmax), Quantitative Thin Film Thickness Monitor (Vmax), Quadrupole Mass Spectrometers (Opal) with supporting UV system.
- Interferable Energy Electron Scatter System with a Microspherical Energy Analyzer in UV supporting system.
- Pressure assisted high temperature hybrid materials fiber filling setup, Optical fiber advanced fusion splicer (HTL, SL1000W01), Spin coater, hot plate, and ultrasonic bath.
- HP Memory readout system (jointly purchased with Prof. Songheun Lee).
- Lecia EM2500 M microscope system, Digital optical microscope (Lecia, DM2700M).
- Open optics spectroscopem, Includes near-infrared camera (ESTIA 1-7-1000) and CCD camera
- Expander laser (Gainesville), Optical Spectrum Analyzer (Vigilant), Ivybridge interferometer setup for phase and amplitude measurements, Spectrometer Privatcon Instruments (holography).
- Optical Spectum (Holographic), Transmission and reflection grating interferometery setup for phase and amplitude measurements, Spectrometer Privatcon Instruments (holography).
- Supercontinuum laser (SC) and tunable with acousto-optic tunable filter (AOTF).
- Ti:Sapphire femtosecond laser system with optical parametric amplifier (Spectra Physics).
- Fourier Transform Infrared Spectrometer, Fourier Spectrometer.

CHEMISTRY
- Shared analytical instruments include FTIR, GC, UV-VIS, ICP-MS (inductively coupled plasma mass spectrometry), high resolution UV-VIS-NIR, DSC, DSC (differential scanning calorimetry), FTIR (Fourier transform infrared), and multiple fluorescence spectrometers.
- Bruker CCD X-Ray Diffractometer and is run by an X-ray crystallographer and chemistry faculty member Dr. Kevin Klausmeyer, which can be used for the analysis of new metallic-arsenic drugs.

GEOLOGY
- Fourier Transform Infrared Spectrometer
- Fourier Spectrometer
- Diode laser and an alpha particle source

BSB
- MRI facility contains 16 MRI's, all MRI's are open access and training and advising are provided by the facility.
- The Mass Spectrometry Center is equipped with three high resolution mass spectrometers, a high resolution magnetic sector instrument (Micromass VG Prostar), an ICP-MS (Perkin Elmer 6300) for elemental analysis, Thermo Sci/Classic, and Thermo Sci/Inorganic, and a high definition (Xe-MS) mass spectrometers.
- The Mass Spectrometry Center's instrumentation includes DNA sequencing (PCR T7-100 Thermocycler and Rotor Gene 6000), Ribo (rRNA) sequencing and Ribo Dye terminator kit, Ribo (rRNA) sequencing and Ribo Dye terminator kit, Ribo (rRNA) sequencing and Ribo Dye terminator kit, and three BSL2 level safety hoods.
- The Center for Microscopy and Imaging Instrumentation includes a 70XU-1000 Confocal Laser Scanning Microscope, a VWR-1000, Transmission Electron Microscope, a JOEL JSM-5410 Scanning Electron Microscope, and a JEOL JSM-5410 Scanning Electron Microscope as well as equipment for sample preparation.
What are the expected outcomes?

- More funding
- New companies, private funding
- Increased PhD production
- More publications
- More research productivity and impact
- Cutting-edge research, new discovery
- Ranking (PhD only)
- Undergraduate student research (REU)
- Expected funding from the new faculty: ~200 K/year

Summary

Most of the top 50 Materials Science and Engineering (MSE) Programs (see phd.org) are known to have started as an institute of cross-disciplinary faculty. Such programs normally offer a PhD degree and/or MS degree. To strengthen the research, the proposed Baylor MSE program will award a MSE PhD through the newly established MSE institute, composed of existing faculty housed in Engineering and Arts & Sciences.

As both the research and PhD program grow with the focused faculty hires in MSE, the BIMSE could become an independent department in the long term (years 10 and beyond).